Chapter 11

Institutional Arrangements

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Introduction

Stormwater management institutions of the 21st century must be equipped to face many challenges. Federal stormwater permitting requirements will affect most cities, even those under a population of 100,000. Funding and staffing are likely to remain tight, even though stormwater regulations and requirements continue to expand. Stormwater management will be only one of a long list of issues that must be addressed by local governments. Given the time and budget constraints typically faced by municipal staffs, they will have to decide where stormwater management lies relative to their other priorities. This is no easy task, given that the benefits of stormwater management can be elusive to quantify.

Furthermore, existing stormwater regulations are transitioning from the promulgation and implementation stages to the enforcement stage, where local governments may face legal challenges, particularly as a result of land use restrictions. Coordination among local, state, federal and private entities is and will continue to be a challenge. Stormwater management institutions will increasingly have to address both water quality and water quantity issues. In some cases, this will require retrofitting existing stormwater quantity structures to address stormwater quality issues. New stormwater management facilities will also need to be financed and constructed. Better education of the public on the significance of stormwater issues will be necessary. Research will be needed to develop new technologies for treating and retaining stormwater runoff. Institutions will have to issue guidance on complicated and often controversial issues such as riparian corridor preservation, impervious area limitations, conservation easements, innovative zoning techniques and other subjects.

Given these challenging tasks, this chapter briefly characterizes the existing models of stormwater management institutions. It then identifies five key characteristics that future stormwater management institutions will need and describes specific technical and administrative issues that these stormwater management institutions will have to address.

Existing Models of Stormwater Management Institutions

There are several existing “models” for stormwater management institutions, including watershed-based committees, local governmental agencies (such as conventional city and county public works departments and regional drainage and flood control districts), stormwater utilities, and privatized institutions. While each of these models is primarily locally based, each must function under federal and state regulations, as well as local ordinances. Any of the models could be appropriate for a given area, depending on the characteristics of the community and the watershed. Ultimately, the decision on what type of stormwater management organization is best for an area should be made by local interest groups. This may involve incorporating stormwater management concepts into an existing institution or creating a new institution (WEF and ASCE 1998). Key characteristics of the four local stormwater management institutional models are briefly highlighted below:

1. Watershed Based Committee/Institutions: "Watershed-based management is a flexible framework integrating the management of all resources--land, biological, water, infrastructure, human, economic--within a watershed" (Horner et al. 1994). These geographically-based groups of multiple public and private entities join together to pool resources and information, and develop and attain water-related goals. The primary benefits are that the institution is geographically based, can provide economies of scale and reduces the "piece-meal" approach to stormwater management. The primary drawback is the difficulty in coordinating a potentially large number of parties, establishing and determining authority, and obtaining funds. The success of watershed-based institutions is also significantly influenced by the size of the watershed (Schueler 1996).

2. Stormwater Utilities: Similar to water and wastewater utilities, municipalities assess fees/taxes to support stormwater utilities and use these funds to implement stormwater programs and facilities. The primary benefit is a steady stream of revenue dedicated to stormwater that does not have to compete with other programs and needs. The primary drawbacks are the lack of perceived need for such institutions (as compared to water and wastewater utilities) and the required creation of a new operating system that needs legal authorization to exist, operate, and assess charges (Horner et al. 1994).

3. Local Agencies: Existing local agencies, such as public works departments and urban drainage and flood control districts, can continue or expand to address stormwater issues. The primary benefit is that, in many areas, these agencies are already in place and have established authority. In addition, local governments are already responsible for land development codes and regulations with an established legal basis for reviewing and approving development plans (Horner et al. 1994). In many cases, smaller basins or subwatersheds are contained within the same political jurisdiction. These subwatersheds are more easily managed than an entire watershed, which may span multiple jurisdictions. A local government with already established authority can manage multiple subwatersheds (Schueler 1996). The primary drawbacks are limited public funding, the red-tape sometimes associated with governmental agencies, and a fragmented approach if a watershed spans several municipalities.

4. Privatization: This involves the developing, selling or partial sale of government-owned enterprises or services. Benefits of privatization include a reduction in

high “soft costs” associated with governmental organizations. Although privatization has proven to be feasible and attractive in the water treatment/distribution and wastewater treatment arenas, privatization of stormwater systems is more problematic. Privatization requires a market-driven service (Rendall 1996). Everyone in a community has the need for a water supply and wastewater treatment and everyone is willing to pay a reasonable price for these services. This is a situation that is potentially appealing to a private business. By contrast, many citizens believe that they do not benefit from expenditures on drainage and flood control systems and are unwilling to pay for such services. A private business would normally not find this to be an acceptable situation, unless the risk can be minimized. Privatization experiences in the water and wastewater arena are not necessarily transferable to the stormwater arena.

The stormwater management institution of the future may incorporate characteristics of each of these models or may look like one of these models in one area and another model elsewhere. The key to the stormwater management organization of the future is that it needs to address local issues and be structured to fit local needs. For example, in many areas, watersheds are contained in a relatively small geographic area; therefore, a watershed-based approach has a limited scope and limited number of stakeholders where coordination of stakeholders is a reasonable task. However, some watersheds, such as the Chesapeake Bay area, may cover several states making a watershed approach more difficult even though it makes the most sense physically. In some communities, environmental issues rank as a higher priority than others. In these areas, a few extra tax dollars a month toward a stormwater utility would be accepted.

The feasibility of innovative stormwater management systems is heavily dependent on trends in federal regulations. At the federal level, responsibility for urban stormwater management is spread among several agencies including the U.S. Environmental Protection Agency (USEPA) (stormwater quality), the U.S. Army Corps of Engineers (flood control and wetlands) and the Federal Emergency Management Agency (FEMA) (flood control). Better integration of these agencies could have a significant positive impact on urban water management (ASCE 1996b). An evaluation of the effect of federal regulations is beyond the scope of this chapter. However, the suggestions presented here are expected to be compatible with the existing federal regulatory framework. Similarly, state involvement in stormwater management is often fragmented between water quality control entities, water quantity entities and other regulatory programs.

Regardless of the “label” that stormwater management institutions receive, they will first need to establish a long-range strategy by defining program objectives, assessing existing conditions, and establishing a program framework. Next, they will need to select and implement a complementary set of BMPs. Finally, they will need to evaluate the program by assessing the effectiveness of these BMPs and then modify their strategy as needed (WEF and ASCE 1998). Stormwater management institutions will be required to address both technical and administrative stormwater-related issues and have the characteristics described in the remainder of this paper.

Required Characteristics of Stormwater Management Institutions

Urban stormwater management institutions for the 21st century will need to incorporate five key concepts:

1. Integration: Given the probability of tight budgets and limited staffs, stormwater institutions will need to coordinate a diversified staff to address both stormwater quality and quantity issues. These personnel will also need to address related engineering, scientific, legal and planning issues. If a watershed-based model is chosen for an area, integration among various stakeholders in the watershed is necessary for the success of the watershed program.

2. Flexibility: Functioning primarily at the local level, stormwater management institutions will need to be flexible enough to meet the specific stormwater challenges of their community and/or watershed. Stormwater management cannot be approached from a "one-size fits all" perspective. Examples of flexibility include consideration of area-specific receiving water characteristics and alternative pollutant control approaches such as pollutant "trading."

3. Efficiency: These institutions must be able to function under tight budgets and limited staffs, while the institutions' responsibilities grow under increased stormwater permitting requirements. Technology such as geographic information systems (GIS), the Internet and databases, should be used where appropriate to efficiently transfer and share information between engineers, planners, scientists, citizens, and others. Successful stormwater management strategies and useful data should be shared throughout the country through publications, conferences, the Internet and other means.

4. Effectiveness: Stormwater management institutions will need to implement stormwater management practices and programs that result in both water quality protection and water quantity control. Monitoring programs should be used to assess the effectiveness of stormwater management practices. Institutions will have to demonstrate that water quality is measurably improving in order to justify stormwater-related expenditures.

5. Responsiveness: Stormwater management institutions will need to be able to respond and adapt to changes in the field. Stormwater facility design criteria must be modified periodically as new technologies become available and as design standards are refined. Local government staff will also need to work diligently to stay abreast of developments related to stormwater. Similarly, considerable effort must be devoted to staying current with computer-based technological advances.

Specific Issues to be Addressed by Stormwater Management Institutions

Financing

The ability of stormwater management institutions to adequately fund and finance stormwater-related expenditures will perhaps be the greatest challenge for these institutions, particularly when the public resists new taxes and service fees. Funding is needed to cover annual operating expenditures such as administration, maintenance and debt service. Financing is needed to pay for capital improvements. Stormwater management institutions will need to:

1. Function under decreased federal funding.

2. Coordinate with state, local and federal agencies and the private sector to allocate funding among various water quality and quantity issues.

3. Prioritize expenditures to meet the growing water-related infrastructure development and rehabilitation costs (i.e., determine the relative priorities of CSO, SSO and urban stormwater management) (Schilling 1996).

4. Set specific and limited achievable goals, given the limited financing (Schueler 1996).

5. Develop a meaningful method of cost-benefit analysis (Jones and Jones 1989). Traditional cost-benefit analysis does not normally occur for expenditures on stormwater management projects, particularly on the water quality side. The main quantifiable benefits of stormwater improvements include improved property and recreational values (ASCE 1996b).

6. Allocate resources to ensure proper maintenance of stormwater facilities.

7. Educate the public to realize that drainage improvements are the financial responsibility of those at the "top of the hill" as well as the "bottom of the hill." The public often believes that those that are damaged by stormwater are those who should pay. Members of the public who "live at the top of the hill" often find it difficult to accept that they are partially responsible for flooding that is occurring at the "bottom of the hill," and hence have an obligation to pay for drainage improvements.

8. Involve local funding sources. Even if non-local funding is available, motivated local water quality advocates are essential for progress in water quality improvement.

9. Develop methods for equitably assigning costs of multi-purpose/multi-group stormwater management programs (Heaney 1986).

Identification of new funding and financing mechanisms may be required, including allocating the costs of new infrastructure between public and private entities. Because the current funding and financing of many watershed-based organizations is tenuous, strategies should include sustaining these organizations, especially if they are being considered for implementing stormwater regulatory compliance. In addition to traditional tax-based and bonding approaches, the following funding and financing sources and/or a combination of these strategies should be considered:

1. Public-Private Partnerships: involves pooling and matching public and private funds. Watershed-based strategies can help to pool funds from multiple public and private entities. Public funds need to be made available for watershed-based initiatives.

2. Fee-in-lieu of: involves charging developers a fee in lieu of requiring construction of certain site-specific BMPs. This fee can be put toward construction of a more cost-effective regional facility.

3. Incentive Programs: provide adequate incentives to encourage developers to implement appropriate BMPs or enter into watershed-based groups.

4. System Development Charges: fees charged to developers when development occurs to help fund services and facilities previously constructed in anticipation of their development. In other words, these deferred fees help recover costs of capacity built into systems to accommodate expected development. SDCs are best used in conjunction with other funding methods (Debo and Reese 1995). Nelson (1995) provides detailed guidance on calculating SDCs.

5. Stormwater Utility: assesses fees/taxes to support stormwater programs and uses these funds to implement stormwater programs and facilities.

6. Privatization: has been successful in the public water supply and municipal wastewater treatment fields because there is an assured revenue stream and because both services are real and perceived necessities. A key issue is “who pays” and in what proportion.

7. Voluntary: through public education, voluntary pollution-prevention and reduction should be encouraged to help states and localities upgrade nonpoint source programs (USEPA 1996).

Staffing: Inter-Disciplinary Approach

For a water quality and quantity management program to be effective, sufficient qualified staff must be provided. In an era of shrinking funding, staffing will be a significant issue. Better communication, coordination and delegation will be required among experts and stakeholders such as aquatic biologists/ecologists, civil/water engineers, economists, attorneys, planners, representatives of environmental and citizen's groups.

Staff members must be cognizant of stormwater quantity and quality management. The subject matter has broadened to include water quality issues such as biology, sediment and wet/dry weather distinctions. The ability to rapidly transfer and share information/data through computerized systems, including the Internet, should be used to reduce redundant efforts among staff members. Institutions will probably need to increasingly "farm-out" work to private consultants, such as aquatic biologists, rather than maintain large staffs of experts. Adjustments may also need to be made as stormwater permitting impacts smaller cities that are able to maintain the staffs required to implement the permitting process.

Administrative Authority

For stormwater management institutions to be effective, they must have adequate state and local legal authority to accomplish their mission. Authority is needed to create, adopt, and enforce ordinances and regulations. Statutory authority must exist for local entities to set up dedicated funding sources, such as a local utility (Horner et al. 1994).

For areas using a watershed approach, an area-wide agency or umbrella organization having authority to require and direct actions by each member political subdivision is needed. This type of authority is not available to most individual watershed management organizations because of multiple jurisdictional involvement or lack of statutory authority. States could assist in establishing appropriate authority by passing enabling legislation and by assisting organizations seeking to address regional stormwater regulatory issues. Considerations include:

- The umbrella organization must have an independent and continuous source of funding.
- One entity must guide implementation.
- The relative authorities and responsibilities of "overlapping" jurisdictions must be determined up-front (Jones 1988).

In any event, public works officials are advised to interact regularly with their colleagues in the city/county/watershed attorney's office because there will increasingly be questions about the extent of the institutional legal authority.

Regulatory Flexibility

The USEPA is increasingly demonstrating its willingness to consider alternatives to the "one size fits all" regulatory approach on wet-weather issues. That is, the USEPA is willing to consider a case-by-case approach. More flexibility and acknowledgment of regional and local constraints should be integrated into the regulatory process. For example, many of the regulatory considerations that apply to streams in humid areas of the U. S. have no application to streams in arid or semi-arid environments (Harris et al. 1996, Stevens 1996). There is emerging recognition that standards and regulations should realistically permit flexibility to respond sensibly to varying physical, biologic and economic conditions and needs. This can be achieved by performing common sense comparisons of benefits, costs, practicality, and cost-sharing alternatives.

A decision support system is necessary to enable flexibility in regulatory administration, that is, a collection of approaches enabling water resource planners to select consistent, appropriate actions with reasonable a priori estimates of the effectiveness of the approach. New control approaches should be developed and demonstrated to enable planners to reach protection goals. USEPA (1996) suggests that there would be value in collating watershed management techniques with information such as on water quality impacts, efficiencies, total costs and sustainability from research projects and demonstrations.

In addition, innovative approaches, such as pollutant trading which has been widely applied in the air arena, have also been applied to the water arena. The USEPA is in the process of establishing a framework for watershed-based pollutant trading. This type of approach incorporates market incentives to further water quality goals and adds flexibility to stormwater regulation (WEF 1996).

Clear Regulations and Standards

Debo and Reese (1995) succinctly summarize the importance of good regulations for achieving stormwater objectives:

> ***The stormwater management structure must bring together the institutional goals, objectives, and administration and the technical solutions using models and master plans by means of regulations, policies and ordinances. When properly conceived, legal authority spans the gap between the two by pairing institutional goals or concerns with technical solutions through the use of performance oriented criteria.***

In the future, more stormwater quality regulation is likely to occur at the state and local level, with a decreased role for the USEPA. As long as there is local commitment, knowledge, and resources, water quality is best managed on a local and/or watershed-basis, with local and state officials and staff making the key decisions. This approach is consistent with the philosophy that specific characteristics of receiving waters should dictate the necessary quality of wet weather discharges. Clear regulations and standards support efficient and effective functioning of a stormwater management institution. Regulatory considerations include:

1. Local problems must be defined clearly to provide meaningful guidance and leadership to all affected interests throughout the development of enabling legislation, regulations, and design criteria.

2. Regulations should define functions and minimum performance objectives of stormwater facilities.

3. Wet weather water quality criteria should be developed that are representative of the specific receiving water—not merely generic water quality criteria/standards.

4. Stormwater quality control programs should strive to protect designated beneficial uses of receiving waters by directing controls at pollutants that impair beneficial uses; however, it must be recognized that in some cases costs may be prohibitive to obtain all beneficial uses (WEF and ASCE 1998).

5. Published design criteria for BMPs, in performance and/or specification terms, must be provided.

6. Regulations must specify minimum submittal requirements for development activities; identify construction inspection requirements and timing; provide for short- and long-term maintenance; and provide for documentation of approvals, special requirements and inspections.

7. Developers proposing construction must obtain water quality impact approvals. There will be much more emphasis on erosion and sediment control in the future, as communities recognize the significance of this problem and the generally poor state of the practice at construction sites.

8. As wet weather criteria/standards become available within the next five to ten years, the BMPs that are now being implemented may no longer be adequate. Stormwater management institutions must plan to handle this scenario.

9. Effectiveness and implementability of nonpoint source regulations should be considered.

10. If the evidence continues to accumulate that aquatic ecosystems are destined to suffer significant damage beyond a certain percentage impervious area,

communities are projected to increasingly adopt impervious area “caps,” such as the limitations that Austin, TX already has in place.

Legal Challenges

Stormwater management institutions are likely to function in an era of increasing litigation related to “wet weather” issues. However, most programs should be able to stand these tests if they are: not in violation of state legislation or municipal charters, equitable, fairly enforced in the best interest of the general public, sound from the scientific and engineering perspectives and well-documented (Debo and Reese 1995).

Nonetheless, much litigation will likely arise from land use-type issues, such as:

1. Impervious area limitations.
2. Maximum slope limitations.
3. Mandatory riparian zone setbacks.
4. Mandatory setbacks from regulatory wetlands.
5. Mandatory setbacks from sensitive environmental features, such as sinkholes in karst terrain.
6. Lot size limitations.

For example, when a local government suggests allowing no more than 20% impervious area within a given watershed to protect urban streams, objections from the development community, governmental leaders and some citizens should be expected.

Regional Solutions

Regional solutions to stormwater issues encompass both physical and administrative approaches including regional structural stormwater facilities, pollutant trading and watershed approaches. Regional approaches to stormwater management should be encouraged and enhanced through state policy and programs.

Watershed-based approaches are often regional by definition since many watersheds incorporate numerous jurisdictions. Watershed/regional approaches to stormwater management make sense from a hydrologic point of view, but are often constrained by administrative issues such as funding, lack of legal authority, and staff continuity. Regional planning entities, while not always organized around drainage basins, are logical entities to address regional stormwater concerns. However, regional planning entities need to be active and have the resources to support stormwater regulatory compliance.

Many communities have come to recognize that larger, “regional” stormwater quantity/quality control facilities are preferable to numerous, smaller, on-site facilities for reasons related to maintenance, appearance, functional effectiveness, including multipurpose use, and cost effectiveness. Unfortunately, many such communities also lack the up-front money necessary to secure optimal sites for regional facilities and to construct the facilities, even though they provide economies of scale in the long run. Stormwater management institutions must help such communities obtain these sites.

Pollutant trading is one regional solution that has been employed in the air and water realms. One critical aspect of successful pollutant trading programs is public relations, including up-front development of partnerships and consensus (Toth 1996). Pollutant trading systems, including both point and nonpoint sources, allow discharge sources to exchange pollution control obligations in order to lower the joint costs of compliance. The potential economic and environmental advantages of trading have drawn increasing broad-based support. In May 1996, the USEPA issued draft guidelines to encourage and facilitate watershed-based effluent trading. Successful trading systems require that government provide three basic conditions: the creation and definition of an allowance, a quantitative restriction on effluent discharge, and the creation and administration of a system of allowance exchange (National Institutes of Water Resources 1996).

Podar et al. (1996) summarized progress of trading programs across the nation and provides examples of such programs (Field et al. 1997). One example in Boulder, CO involves the decision to improve stream flow, restore the riparian zone and install some nonpoint source control measures rather than upgrade the municipal treatment facility to remove more ammonia. Boulder has saved up to $3.5 million in capital costs and gained improvements to the environment, including improved streambank stabilization, reduced streambank erosion, improved filtration of runoff, improved fish habitat, more continuous protected riparian zone for wildlife and increased wetland area. Pollutant trading programs such as this one should be encouraged and solutions to administrative difficulties should be shared nationally.

Interest in watershed approaches has also increased, as evidenced by over 300 papers presented at the “Watershed ‘96” conference in Baltimore (Field et al. 1997). The watershed approach is also being driven by federal natural resources management policy. One of the key motivations for watershed-based approaches is enhanced local control and improved economic efficiency. Cost-savings can be realized through coordinated monitoring efforts and cost-effective pollutant removal for the watershed as a whole. Joint efforts include the pooling of funds, expertise and capital. In many cases, the benefits of joint efforts are multiplied beyond the initial savings. For example, the benefits of effective monitoring enable better decision-making based on more accurate and complete data (Brewer and Clements 1996).

Total Risk Management

Local governments are often involved with a variety of natural hazards, such as fire, wind, landslides and earthquakes. Stormwater-related issues are just one category of the total risks facing local governments. Risk management decision-support tools should be used to optimize the use of various control strategies/technologies for stormwater management including retrofitting, upstream pollution prevention, land management, and non-structural or minimal structural approaches (USEPA 1996). For example, risk management approaches such as the Watershed Analysis Risk Management Framework (WARMF) can be used to select management approaches based on cost, effectiveness and risk of failure of various management alternatives (Chen et al. 1998). The stormwater management institution should develop acceptable levels of risk on a watershed by watershed basis.

Maintenance

Even the best stormwater management programs and facilities fail without proper maintenance. Resources must be allocated to ensure proper maintenance of stormwater facilities. When requirements to install stormwater BMPs are imposed on private parties, without the assurance that proper maintenance will be practiced, the facilities fail to function, fall into disrepair, become unsightly and are viewed as a nuisance (Zeno and Palmer 1986). The stormwater management institution should set up requirements and guidance for appropriate maintenance. Clear policy should be developed clearly specifying who is responsible for maintenance (Horner et al. 1994).

Monitoring/Evaluation

Regular monitoring and evaluation helps to determine whether the stormwater program is achieving its goals and being administered in an efficient, cost-effective manner. Procedures can include actual environmental monitoring such as water chemistry, biological communities (e.g., aquatic life), and sediment chemistry. Monitoring program objectives must be clearly identified when initiating the monitoring program (Horner et al. 1994). Stormwater monitoring should include quick and relatively inexpensive biological tests to establish the toxicity of stormwater runoff. These tests and other chemical tests (again, which are straight forward and inexpensive) will enable the determination of problematic constituents in the stormwater by local stormwater institutions.

Clear guidance should be developed and distributed on developing practical monitoring programs that represent a compromise between the number of samples suggested by thorough statistical analysis and economic and resource considerations. Performance assessment data from existing BMP databases can be used to determine the amount of data required to evaluate the performance of new BMPs. Clear monitoring guidance is not available for several biological and ecological properties of stormwater. As more data become available, the role of BMPs in minimizing or reducing the potential toxicity of stormwater runoff should be provided (WEF and ASCE 1998).

When determining pollutant removal guidelines, more emphasis should be placed on defining the hydrologic and water quality characteristics of the receiving water. Moreover, more public and private entities should have the capability to perform these baseline studies, without an inordinate amount of training and at relatively low cost. A better understanding of the receiving water characteristics would include:

- Determining a suitable design flow representative of wet weather conditions.

- Enhancing the understanding of dose/frequency/response relationships. That is, how often can the relevant organisms receive how much of a given pollutant?

Similarly, the use of ecological endpoints or “targets” should be increasingly used to define objectives for urban stormwater quality management. This type of approach is consistent with an overall, integrated watershed management approach that links studying streams, groundwater, aquatic communities and other environmental components of interest. It also includes studying municipal WWTP discharges, industrial waster sources, CSOs, sanitary sewer overflows and discharges (WEF and ASCE 1998).

A variety of new monitoring approaches are available including a “stress-response” framework, risk assessment approaches, environmental effects monitoring and other methodologies. One innovative approach uses in situ probes and biomonitors that involve putting organisms in place for brief periods of time to measure phenomena not measured by typical chemical procedures or using special in situ organisms to detect impacts. One challenge with biomonitoring-type approaches is increased difficulty with interpreting data, whereas chemical monitoring allows easier comparison to water quality standards. As monitoring systems develop over the next decade, a balance will need to be reached between chemical and biological monitoring approaches (WEF and ASCE 1998).

Finally, stormwater management institutions should regularly evaluate the effectiveness of monitoring programs and be willing to adapt to improve their effectiveness. This evaluation should include analyzing results of water quality monitoring, return on expenditures (i.e., determining if money invested is providing benefits worth the costs), and public education.

Modeling and Performance Auditing

As a follow-up to monitoring and evaluation, modeling can be used to supplement monitoring efforts with simulations that allow prediction of both discharge and receiving water quality (WEF and ASCE 1998). However, selection of appropriate models and collection of data necessary to run these models can be time-consuming and challenging in some cases. A WEF and ASCE (1998) summary indicates that models can be used to achieve the following objectives:

1. Characterize the urban runoff with regard to temporal and spatial detail, and concentration/load ranges.

2. Provide input to a receiving water quality analyses.

3. Determine effects, magnitude , locations and combinations of control options.

4. Perform frequency analysis on quality parameters (to determine return periods of concentration/loads).

5. Provide input to cost-benefit analyses.

Although models do not replace a well-planned field monitoring program, they can sometimes be used to extend and extrapolate measured data and enhance field-sampling results.

Acquisition of high-quality data needed to support modeling affect the level of effort and costs associated with the modeling effort. Two general types of data required for modeling include input parameters needed in order for the model to function and data needed for calibration and verification. Input parameters include both quantity and quality-related data. Examples of quantity-related data include rainfall information, area, imperviousness and runoff coefficient. Examples of quality-related data include constituent concentration, median value and coefficient of variation, regression relationships, and buildup/washoff parameters. Calibration and verification data may include sets of measured rainfall, runoff and quality samples with which to test the model (WEF and ASCE 1998).

Nonstructural Source Control Strategies

Management institutions will need to place more emphasis on nonstructural source controls because, in most cases, pollution prevention is more cost effective than pollution correction. Historically, stormwater programs focused on flood control and structural controls. In the future, multilevel stormwater management is needed that combines nonstructural source controls with structural treatment controls (WEF and ASCE 1998).

Examples of source controls include: public education, recycling, stenciling stormwater inlets, removing illicit discharges, pollution prevention practices for industrial and commercial sites, modifying deploying methods and substituting products for lawn/garden care and roadway chemicals, and non-toxic product substitution from materials of construction and surface coatings/preservatives exposed to rainfall runoff (USEPA 1996). Land use ordinances including cluster zoning, conservation easements, and mandatory buffer zones are additional nonstructural strategies to protect stormwater quality. Watershed-based organizations are particularly well suited to implementation of nonstructural approaches. Innovative source control practices are expected to flourish in the future in response to stormwater quality regulations just as RCRA compliance spawned many activities that have eliminated/modified chemical usage.

Retrofitting

As the shift to recognizing the significance of stormwater quality issues continues to occur, retrofitting of existing stormwater quantity structures to improve their quantity function and also serve water quality purposes will occur. For example, to improve pollutant removal, detention ponds must be changed to increase residence time, minimize short-circuiting, and provide shallow littoral zones planted with appropriate native wetland plants. Dry detention, used widely for flood control, typically provides little pollutant removal benefits because of its short detention time, bottom discharge control, and paved channels. In many locations, codes require that street curbs and gutters be used with storm sewers to eliminate runoff ponding, even for short time periods. Many localities are eliminating this requirement to promote infiltration with grassed swales, decrease runoff volume, and improve pollutant removal (Horner et al. 1994).

Walesh (1991, 1998) reviews the historic development of the use of storage for stormwater management in the U.S. as the basis for the current retrofit potential. He stresses looking at the possibility of retrofitting existing facilities for quantity-quality control before constructing new facilities. Lower cost solutions may result. Various quantity-quality case studies are provided. Walesh and Carr (1998) describe retrofitting a combined sewer system, by means of controlled on and below street storage of storm water, to cost-effectively solve basement flooding throughout an 8.6 square mile community. Construction costs for the largely implemented system are one third of the cost of traditional sewer separation.

Technology Transfer

Technological advances offer great potential to enhance stormwater management. Conducting more "real time" analysis and system operation should increasingly become more feasible (Schilling 1996, Field et al. 1997). GIS will increasingly be linked with hydrologic modeling and decision support systems, thereby facilitating master planning. For example, the USEPA recently released a package called BASINS (Better Assessment Science Integrating Point and Nonpoint Sources) that provides links to nonpoint models including HSPF and QUAL2E using ArcView (Lahlou et al. 1996). The ability to present results of engineering analyses and to depict structural improvements will be greatly enhanced through new technology, and this will be valuable for educating the public and decision makers. Hydrologic computer models should be even easier to use than they are now. Similarly, reliable stormwater quality software will likely be developed and be easy to use. Even though stormwater management is expected to continue to occur primarily at the local level, local staff should be able to take advantage of national databases with design and implementation data to determine what measures are most appropriate for their communities. For example, the USEPA and ASCE are in the process of developing a national stormwater BMP database that will provide this type of information (ASCE 1996a).

Guidance for Practices Such as Riparian Corridor Preservation and Restoration

More guidance is needed for practices such as riparian corridor preservation and restoration. The virtues of this practice are becoming increasingly recognized, but the difficulties and limitations should be discussed as well. In many urban areas, to accomplish marked improvements in water quality and aquatic life, retrofitting stormwater quality enhancements and stream habitat improvements is necessary. Retrofitting includes: "restoring degraded urban water courses to either their original condition, or to a condition that is ecologically and aesthetically satisfactory. This includes not only the prevention of unwanted erosion, scour, and sediment deposition, but also the new methods for regaining some of their aesthetic and ecological qualities and contributing to water quality enhancement, while at the same time retaining their flood carrying capacity (which is why the streams were modified in the first place) (Torno 1989)."

Riparian corridor preservation is used as an example of the types of issues that need to be considered when preparing guidance for these practices. The value of protecting, restoring, and enhancing riparian corridors along streams in urban settings has been widely recognized. However, specific guidance on how to preserve, restore, and/or enhance riparian corridors has been lacking, particularly on the institutional side. In the last few years, efforts have begun to develop this type of guidance and should continue. For example, Herson-Jones et. al. (1995) recently provided guidance on riparian buffer programs used to mitigate the impact of urban areas on nearby streams based on a national survey and literature review. They recommend a step-by-step approach including identifying program objectives, assessing site conditions, determining a program structure, establishing minimum or standard width requirements, defining exceptions of rules for increasing or decreasing the standard width and evaluating the potential water quality benefits of the buffer program. They also address issues such as plan review and inspection, long-term buffer management, maintenance, enforcement, construction, post-construction and establishment of local ordinances.

Similarly, many federal agencies recently joined together to write Stream Corridor Restoration: Principles, Process, Practices, which provides guidelines for stream restoration and is expected to be released in 1998 (Tuttle and Brady 1996). A manual focusing on the restoration of urban streams was produced in the midwest by a partnership of federal, state and local government units (Newbury et al. 1998).

In conjunction with technical issues, guidance should address socioeconomic issues such as:

1. Selecting a variable versus fixed width approach (a "variable width" approach to delineating a buffer zone makes good sense technically, but a "fixed width" approach is much easier to administer).

2. Convincing reluctant developers and other property owners of the merits of leaving riparian zones undeveloped.

3. Legal aspects of buffer zone restrictions.

4. Promoting restoration of channels (Brown et al. 1996).

Public Involvement and Education

Public involvement is imperative to foster community ownership in stormwater programs (Debo 1982, Walesh 1993, Wright 1982). The public must be better informed to recognize that stormwater runoff is just as serious a source of pollution as CSOs. The public perception must shift to recognize the need for stormwater management. Citizens must understand how everyday activities contribute to stormwater problems. Simple pamphlets inserted into utility bills, books, videos, and displays at local events have been used successfully. Special programs such as “adopt-a-stream,” and “eco-neighborhoods” are proving successful in encouraging citizens to buy into programs (Horner et al. 1994).

Furthermore, to obtain consensus and support needed for implementation of stormwater management programs, watershed stakeholders must be involved in the program development. Stakeholders can include agencies, organizations, and individuals that will be affected by the program. The ideal group of stakeholders would include interested citizens, developers, environmentalists, consultants, planners, property owners and public agencies. Early and frequent stakeholder involvement is important to develop consensus in what could otherwise be a controversial process. Issues on which participation should be sought include: sharing data and mapping, setting priorities, establishing goals, developing development criteria, measuring success, and reviewing and approving stormwater programs (Schueler 1996, Walesh 1997).

An appropriate balance must be established between the need for adequate public input versus excessive public involvement, which can actually impede progress. Given the increasing knowledge and interest of stakeholders, Walesh (1997) notes that the old DAD (decide-announce-defend) approach to urban water management must give way to the more effective POP (public owns project) model.

Conclusion

Stormwater management institutions can incorporate a variety of characteristics of the existing stormwater models or a combination of these models. The organization should be locally based with adequate legal authority to create and enforce stormwater criteria and regulations. Stormwater issues should be tackled on a limited geographic scale, preferably at the subwatershed level. The stormwater utility approach is probably the most reliable method for ensuring funds dedicated to stormwater management. Although the future of privatization in the stormwater arena is not clear, market-based incentives such as pollutant “trading” in a watershed will clearly become more popular. Watershed-based organizations face a number of hurdles. Their role in educating the public regarding stormwater issues could be significant. States could assist by performing more than a permitting role with possible activities including providing guidance to and enhancing regional cooperative efforts.

The stormwater management organization will be faced with challenges such as retrofitting existing stormwater quantity structures to meet stormwater quality needs, developing guidance for riparian corridor preservation, meeting legal challenges on land use regulations, and monitoring and maintenance of stormwater structural and nonstructural BMPs. The ability to rapidly share stormwater-related information through the use of technology, such as the Internet and GIS, should help to facilitate progress in the stormwater arena. Public involvement and education will also be keys to the success of future stormwater management efforts.

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